Erebus volcano, Ross Island, Antarctica: Recent studies, forthcoming publications

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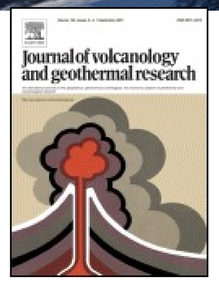
Forthcoming Publication



Journal of Volcanology and Geothermal Research

Special Issue: Erebus Volcano, Antarctica

Edited by Clive Oppenheimer and Philip Kyle

A special issue of the journal Volcanology and Geothermal Research (JVGR) is currently in preparation and will be published in November 2008. The primary purpose of this poster is to bring your attention to this pending publication. All of the manuscripts are available on the JVGR web-page (http://www.sciencedirect.com/science/journal/03770273).

At this time (20 August 2008) 17 manuscripts have been accepted for publication.

SUMMARY

The 3794 m high Erebus volcano is the most active in Antarctica and contains a unique persistent convecting lake of anorthoclase phonolite magma which was discovered in 1972. Erebus has small strombolian eruptions and is proving to be the perfect volcano to understand such eruptions and magma chamber processes. Easy access from McMurdo Station aids in the investigations. Over the past 10 years a team of investigators has examined many aspects of the volcanology, petrology, geochronology and geophysics of Erebus volcano and the results of some of these studies are being published in a Special Issue of the Journal of Volcanology and Geothermal Research due out in November 2008. The special issue contains 17 papers and a Preface. Here we present abstract for 16 of the papers in the issue.

PETROLOGIC STUDIES

GEOCHEMISTRY AND MINERALOGY OF THE PHONOLITE LAVA LAKE, MOUNT EREBUS VOLCANO, ANTARCTICA: 1972 - 2004 AND COMPARISON WITH OLDER LAVAS

Peter J. Kelly, Philip R. Kyle, Nelia W. Dunbar, Kenneth W.W. Sims

Mount Erebus, Antarctica, is a large (3794 m) alkaline open-conduit stratovolcano that hosts a persistent convecting and degassing lake of anorthoclase phonolite magma. The composition of the lake was investigated by analyzing glass and mineral compositions in lava bombs (tephra) erupted between 1972 and 2004. Olivine, clinopyroxene, titanomagnetite, fluor-apatite, and matrix glass compositions are invariant and show that the magmatic temperature (~1000°C) and oxygen fugacity (ΔlogFMQ = -0.9) have been constant. Anorthoclase phenocrysts up to 10 cm in length show complex textural and compositional zoning that reflects growth during convection in a P_{H2O} *gradient under isothermal* conditions. Bomb textures and anorthoclase compositions suggest that crystallization occurs at low degrees of effective undercooling and is controlled by shallow degassing of water in the conduit. Minor variations in eruptive activity in the last 31 years are decoupled from magma compositions. The variations probably relate to changes in conduit geometry within the volcano and/or variable input of CO_2-rich volatiles into the upper-level magma chamber from deeper in the system. Eleven bulk samples of phonolite lava from the summit plateau that range in age from 0 ± 4 ka to 17 ± 8 ka were analyzed for major and trace elements. Small compositional variations are controlled by anorthoclase content. The lavas are indistinguishable, and the composition of the lava lake has been constant to within analytical uncertainties, between erupting lavas and those erupted 17 ka ago.

Sr, Nd, Hf, AND Pb ISOTOPE PERSPECTIVE ON THE GENESIS AND LONG-TERM EVOLUTION OF ALKALINE MAGMAS FROM EREBUS VOLCANO, ANTARCTICA

Kenneth W. W. Sims, Janne Blichert-Toft, Philip R. Kyle, Sylvain Pichat, Jurek Bluzstajn , Peter Kelly, Lary Ball, Graham Layne

New Nd, Hf, Sr, and high-precision Pb isotopic data for 44 lava and tephra samples from Erebus volcano covering its entire compositional range from basanite to phonolite, and representing all three phases of the volcano's life from 1.3 Ma to the present, are reported. Isotopic analyses of 7 samples from Mt. Morning and the Dry Valley Drilling Project (DVDP) are given for comparison. The Erebus volcano samples have radiogenic $^{206}Pb/^{204}Pb$, unradiogenic $^{87}Sr/^{86}Sr$, and intermediate $^{143}Nd/^{144}Nd$ and $^{176}Hf/^{177}Hf$, and lie along a mixing trajectory between the two end-member mantle components DMM and HIMU. The Erebus time series data show a marked distinction between the early-stage basanites and phonotephrites, whose Nd, Hf, Sr, and Pb isotope compositions are variable (particularly Pb), and the later, evolved phonolitic lavas and bombs, whose Nd, Hf, Sr, and Pb isotope compositions are essentially invariant. Taken together, these samples define a trend of decreasing isotopic variability with increasing extent of differentiation, indicating that magma mixing has played a fundamental role in establishing the isotopic and compositional uniformity of the stage-three phonolites. In-situ analyses of Pb isotopes in melt inclusions hosted in an anorthoclase crystal from a 1984 Erebus phonolite bomb and in an olivine from a DVDP basanite are uniform and identical to the host lavas within analytical uncertainties, suggesting that, in both cases, the magma was well mixed at the time of its incorporation into these different phases.

REFINEMENT OF THE YOUNGER GEOLOGIC HISTORY OF EREBUS VOLCANO, ANTARCTICA USING $^{40}Ar/^{39}Ar$ AND ^{36}Cl AGE DETERMINATIONS

Peter J. Kelly, Nelia W. Dunbar, Philip R. Kyle, William C. McIntosh

Six furnace step-heating $^{40}Ar/^{39}Ar$ and 3 cosmogenic ^{36}Cl age determinations are used to refine the eruptive history of Erebus volcano. The Northwest lava flow on the summit plateau has a new anorthoclase $^{40}Ar/^{39}Ar$ age of -3 ± 7 ka (2σ uncertainty), indistinguishable from 1 ± 5ka reported by Harpel et al., (2004). The weighted-mean age for the Northwest flow is 0 ± 4 ka. Anorthoclase from 3 lava flows on the caldera rim give $^{40}Ar/^{39}Ar$ ages of 23 ±12, 81 ± 3 and 172 ± 10 ka. The ages support the presence of a second, younger, superimposed caldera near the southwestern margin of the summit plateau and greatly extend the age of lavas exposed in the caldera walls. A phonolite lava bomb sitting on a parastic trachyte cone at Bomb Peak (1960 m elevation) has an anorthoclase age of 23 ± 3 ka. The location of the vent that erupted the bomb is unknown but likely to be nearby. Trachyte from "Ice Station" on the eastern flank is 159 ± 2 ka, similar in age to those at Bomb Peak and Aurora Cliffs. The widespread occurrences of trachyte on the eastern flank of Erebus suggest a major previously unrecognized episode of trachytic volcanism. Cosmogenic ^{36}Cl ages were determined for 3 summit lava flows previously dated by the $^{40}Ar/^{39}Ar$ method. At an assumed erosion rate of 1.5 mm/ka ^{36}Cl cosmogenic ages are 6.0 ± 0.5 ka (2σ uncertainty) for the Ice Tower Ridge flow, 4.9 ± 0.4 ka for Tower Hut flow, and 6.5 ± 0.6 ka for the Northeast flow. The ^{36}Cl ages are similar to or slightly younger than $^{40}Ar/^{39}Ar$ ages for these lavas, and confirm the overall young age of summit lava flows.

EXACT ACTIVE TEPHROSTRATIGRAPHY OF MOUNT EREBUS VOLCANO, ANTARCTICA

S.J. Harpel , P.R. Kyle, N.W. Dunbar

Tephra erupted from Mount Erebus volcano was collected from glacial ice, firn, and a modern strombolian eruption. The eruption mechanisms responsible for the tephra were determined using shard morphologies observed using scanning electron microscopy. Electron microprobe analyses of shards were made to ensure that all of the tephra are derived from Erebus volcano and to examine any chemical variability. The glass shards are all phonolitic and show several subtle stratigraphically controlled geochemical trends. Trace element analyses of bulk tephra samples are mainly homogeneous except for slight variations due to varying feldspar contents. The majority of the tephra resulted from phreatomagmatic eruptions with lesser numbers having a strombolian origin. A significant number of tephra have mixed phreatomagmatic-strombolian origins. A plinian eruption and large phreatomagmatic eruption deposited tephra up to 200 km from Erebus. Glass droplets observed in the tephra were produced in both phreatomagmatic and strombolian eruption mechanism. Budding ash morphology has not been previously reported from tephra fall deposits and appears as a parent melt bleb with small spheres quenched during the process of pinching off. Clustered and rare single xenocrystic analcime crystals, undifferentiated zeolites, and clay are present and were likely entrained into the tephra from a hydrothermal system present prior to eruption.

AIRBORNE LASER SWATH MAPPING OF THE SUMMIT OF EREBUS VOLCANO, ANTARCTICA: APPLICATIONS TO GEOLOGICAL MAPPING OF A VOLCANO

Bea Csatho, Toni Schenk, Philip Kyle, Terry Wilson, William B. Krabill

The lidar observations reported here have provided the first high precision topographic data on the active craters of Erebus volcano, Antarctica. Digital elevation data are invaluable for geomorphic analysis of volcanoes especially when combined with methods to automatically extract landscape features. The data are indispensable for studying eruptive events and volcano-tectonic processes. Airborne laser scanning or lidar is a rapidly emerging technology to map surface topography with high accuracy and detail, comparable to a 1:1000 scale map. In the austral summer of 2001–2002 airborne laser scanning data were collected in Antarctica over the summit plateau of Erebus volcano. We describe the high-resolution data set from Erebus, products derived from the data and demonstrate how extracted topographic features can be used in the geomorphic analysis of volcanoes. Background is presented on the airborne laser scanning method and on the accuracy estimation of laser points. We describe the computation of a high-resolution DEM with a grid size of 2 m×2 m for the summit area of Erebus volcano. Errors in the DEM are assessed using independent ground-based GPS data and the RMS error is estimated to be 0.39 m. Visualization methods reveal topographic features that are very useful for geomorphic analysis. Automatic feature extraction and processing is necessary to exploit the high-resolution and accurate elevation data. Methods are described to extract 1D and 2D features and organize them for subsequent analysis. Fitting analytical functions to 3D point clouds or DEMs is particularly effective in extracting topographic features, including planes, higher order surfaces, cones, and conic sections. These methods are used to obtain a quantitative description of the calderas and modern-day crater of Erebus. Especially valuable re the measured surface areas if the lava lakes as these control thermal emissions and gas fluxes from the volcano. Examination of the surface elevations of Ray Lava Lake,Werner Vent and Active Vent indicates that the active vents were more or less in magmastatic equilibrium in 2001 December. Conic segments are fitted to mapped

GEOPHYSICAL STUDIES

VIDEO AND SEISMIC OBSERVATIONS OF STROMBOLIAN ERUPTIONS AT EREBUS VOLCANO, ANTARCTICA

R.R. Dibble, P.R. Kyle, C.A. Rowe

Between 1986 and 1990 the eruptive activity of Erebus volcano was monitored by a video camera with on-screen timecode and recorded on video tape. Corresponding seismic and acoustic signals were recorded from a network of 6 geophones and 2 infrasonic microphones. Two hundred Strombolian explosions and three lava flows which were erupted from 7 vents were captured on video. In December 1986 the Strombolian eruptions ejected bombs and ash. In November 1987 large bubble-bursting Strombolian eruptions were observed. The bubbles burst when the bubble walls thinned to ~20cm. Explosions with bomb flight-times up to 14.5 s were accompanied by seismic signals with our local size estimate, "unified magnitudes" (mu), up to 2.3. Explosions in pools of lava formed by flows in the Inner Crater were comparatively weak. Changes in eruptive activity occurred in 1987 when the lava lake was buried by a landslide from the crater wall. Two new vents formed and seismic activity peaked as the landslide was ingested. Lava flows from a vent on the eastern side of the crater formed small lakes and a vent on the north began to flow in 1990. By December 1990 the entire floor of the Inner Crater was buried by up to 20000 m3 of new lava. Different families of nearly identical eruption earthquakes occurred each year, whose foci were contained within small, shallow volumes. Immediately after several bubble-bursting explosions, vortex rings of the gaseous core were observed. The vortex was seen to taper downwards to about half its diameter at the bottom. Our observations confirm models of Strombolian eruptions suggesting they arise from gas slugs rising through a conduit into a flared vent.

MOMENT TENSOR INVERSION OF VERY LONG PERIOD SEISMIC SIGNALS FROM STROMBOLIAN ERUPTIONS OF EREBUS VOLCANO, ANTARCTICA

R. Aster , D. Zandomeneghi, S. Mah, S. McNamara, D.B. Henderson, H. Yarbrough, K. Jones

Strombolian eruptions from the long-lived lava lake of Mount Erebus Volcano, Ross Island, Antarctica, generate repeating Very Long Period (VLP) signals, containing energy between approximately 30 and 5 s, that persist for several minutes and through the post-eruptive refilling of the lava lake. The initial approximately 10 s of this signal is moderately variable, particularly with respect to its initial polarity, while the following VLP coda has been observed to be stable since the earliest VLP observations were made (1996). To estimate forces and force couples consistent with the Erebus VLP signature, we perform moment tensor inversions for point sources using high signal-to-noise data stacks from the six-station, 18-component broadband seismographic network and Green's function forward calculations that incorporate topography. We infer a shallow (approximate depth of less than 400 m below the lava lake surface) source centroid that underlies the center to the northwestern rim of the main crater, east and north of the lava lake. Integrated Mii functions over the predominant (180 s) signal duration of VLP events show that the net scalar moments for these events are on the order of 4×1013 Nm (corresponding to a moment magnitude mw ≈3) for typical sized VLP events. Moment rate tensors which characterize force couple components are dominated (85 – 97% of variance) by dilatational components. Approximately 25% of the data variance is attributable to single forces that are attributable to oscillatory reaction forces caused by fluid transport, however, the relative contributions of vertical forces and couples with this sparse network is poorly resolved for these shallow sources. The generally high degree of repeatability in the VLP signal across thousands of eruptions over the past decade indicates that the response of the conduit system to gas slug arrivals and associated pressure oscillations is stable, consistent with the generally unchanging surface manifestation of the convecting lava lake system, and arguing for a thermally and dynamically stable conduit system beneath the lava lake.

INFRASONIC CRACKING OF LARGE BUBBLE BURSTS AND ASH VENTING AT EREBUS VOLCANO, ANTARCTICA

Jeremy Johnson, Richard C. Aster, Philip R. Kyle, William C. McIntosh

Explosive degassing at Erebus volcano produces infrasound that can be used to locate, characterize, and quantify eruptive activity from multiple vents. We use a three element distributed microphone network to pinpoint eruption sources and track the activity at the prominent vents through time. Eruptive mechanisms for both source types are analyzed in conjunction with the telemetered time-synced video imagery. We identify two commonly active vents corresponding to: 1) large (often > 10 m diameter) bubble bursts at the free surface of a persistent phonolitic lava lake, and 2) ash-rich eruptions from a constricted vent located ~80 m from the lava lake. During a 3-month study interval from 6 January to 13 April 2006 we identified and mapped more than 350 eruptive sources from the lava lake and 20 sources from the ash vent. Lava lake events are characterized by high-amplitude infrasonic transients that reflect rapid (less than a few s) acceleration and rupture of magma bubble films followed by an explosion of pressurized gases. Precise infrasonic localization of the lava lake events to accuracies of a few m indicates variable bubble source locations across a 40 by 50 m region spanning the lava lake. Spatial variability is corroborated by the video data. In contrast, degassing from the ash vent produces longer-duration (tens of s), lower amplitude transients that reflect a more sustained, jetting release of gas. Ash is occasionally ejected from the ash vent, but is not observed in the video. Because infrasound networks can operate continuously in all weather conditions and during both diurnal and seasonal polar darkness, and are easily incorporated into automatic processing, they significantly contribute to the completeness and quantification of eruption catalogues for Erebus.

This study inverts for acoustic source volume outflux and momentum imparted to the atmosphere using a three station pressure transducer network distributed about the actively erupting Erebus lava lake. A simple monopole point source model is initially modeled to estimate explosively injected gas mass, which is found to range between 1,000 kg and 19,000 kg for a suite of 282 explosions recorded between January 6 and April 13 2006. Though these gas quantities are compatible with bubble volumes at rupture (as estimated from explosion video), perfectly isotropic radiation is not realized in the recorded acoustic wavefield for many explosive events. A point source acoustic dipole with arbitrary axis and strength is subsequently invoked and found to provide a better fit to the recorded infrasound data. This dipole source axis, corresponding to inferred short-duration material jetting, is observed to change for different events. Furthermore, its general orientation is corroborated by directional emissions of ejecta seen in Erebus eruption video footage. Although three azimuthally distributed stations are insufficient to fully characterize the eruptive acoustic source we speculate that a monopole with a minor amount of dipole radiation may reasonably explain the apparent directivity and primary features of the recorded infrasound.

4D VELOCITY OF STROMBOLIAN ERUPTIONS AND MAN-MADE EXPLOSIONS DERIVED FROM MULTIPLE DOPPLER RADAR INSTRUMENTS

Alexander Gerst, Matthias Hort, Philip R. Kyle, Malte Vöge

We used a novel system of three continuous wave Doppler radars to successfully record the directivity of i) Strombolian explosions from the active lava lake of Erebus volcano, Antarctica, ii) eruptions at Stromboli volcano, Italy, and iii) a man-made explosion in a quarry. Erebus volcano contains a convecting phonolite lava lake, presumably connected to a magma chamber at depth. It is one of the few open vent volcanoes that allow a direct observation of source processes during explosions. Its lava lake is the source of frequent violent Strombolian explosions, caused by large gas bubbles
bursting at the lake surface. The exact mechanism of these bubble bursts is unclear, as is the mechanism of the creation of the infrasound signal accompanying the explosions. We use the Doppler radar data to calculate the directivity of Strombolian eruptions at Erebus. This allows us to derive information about the expected type of infrasound source pattern (i.e. the role of a dipole in addition to the monopole signature) and the physical structure of the volcano.
We recorded 10 large explosions simultaneously with three radars, enabling us to calculate time series of 3D directivity vectors (i.e. effectively 4D), which describe the direction of preferred expansion of the gas bubble during an explosion. Such directivity information allows a comparison to dipole infrasound radiation patterns recorded during similar explosions only a few weeks later. Video observations of explosions support our interpretation of the measurements. We conclude that at Erebus, the directivity of explosions is mainly controlled by random processes. Since the geometry of the uppermost conduit is assumed to have a large effect on the directivity of explosions, the results suggest a largely symmetrical uppermost conduit with a
vertical axis of symmetry. For infrasound recordings, a significant dipole signature can be expected in addition to the predominant monopole signature.

ACKNOWLEDGEMENTS

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THERMAL STUDIES

MULTI-INSTRUMENT REMOTE AND IN SITU OBSERVATIONS OF THE EREBUS VOLCANO (ANTARCTICA) LAVA LAKE IN 2005: A COMPARISON WITH THE PELE LAVA LAKE ON THE JOVIAN MOON IO

Ashley Gerard Davies, Julie Calkins, Lucas Scharenbroich, R. Greg Vaughan, Robert Wright, Philip Kyle, Rebecca Castaño, Steve Chien, Daniel Tran

The stable, persistent, active lava lake at Erebus volcano (Ross Island, Antarctica) provides an excellent thermal target for analysis of spacecraft observations, and for testing new technology. In the austral summer of 2005 visible and infrared observations of the Erebus lava lake were obtained with sensors on three space vehicles Terra (ASTER, MODIS), Aqua (MODIS) and EO-1 (Hyperion, ALI). Contemporaneous ground-based observations were obtained with hand-held infrared cameras. This allowed a quantitative comparison of the thermal data obtained from different instruments, and of the analytical techniques used to analyze the data, both with and without the constraints imposed by ground-truth. From the thermal camera data, in December 2005 the main Erebus lava lake (Ray Lake) had an area of ≈820 m². Surface colour temperatures ranged from 575 K to 1090 K, with a broad peak in the distribution from 730 K to 850 K. Total heat loss was estimated at 23.5 MW. The flux density was ≈29 kW m⁻². Mass flux was estimated at 64 to 93 kg s⁻¹. The best correlation between thermal emission and emitting area was obtained with ASTER, which has the best combination of spatial resolution and wavelength coverage, especially in the thermal infrared. The high surface temperature of the lava lake means that Hyperion data are for the most part saturated. Uncertainties, introduced by the need to remove incident sunlight cause the thermal emission from the Hyperion data to be a factor of about two greater than that measured by hand-held thermal camera. MODIS also over-estimated thermal output from the lava lake by the same factor of two because it was detecting reflected sunlight from the rest of the pixel area. The measurement of the detailed temperature distribution on the surface of an active terrestrial lava lake will allow testing of thermal emission models used to interpret remote-sensing data of volcanism on Io, where no such ground-truth exists. Although the Erebus lava lake is orders of magnitude smaller than the lava lake at Pele on Io, the shape of the integrated thermal emission spectra are similar. Thermal emission from this style of effusive volcanism appears to be invariant. Excess thermal emission in most Pele spectra (compared to Erebus) is due to the large (~300 m) areas of cooled lava flows that surround the active lava lake.

GROUND BASED THERMAL IMAGING OF PHONOLITE LAVA LAKES AT EREBUS VOLCANO, ANTARCTICA

Julie A. Calkins, Clive Oppenheimer, Philip R. Kyle

Erebus volcano, Antarctica (3794 m) is host to a persistent phonolite lava lake and several active fumarolic vents. The main activity at Erebus Volcano in December 2004 was manifested in two convecting lava lakes within the Inner Crater. The long-lived Ray Lake, ~1400 m² in area, was the site of up to 10 small strombolian eruptions per day. A new transient ~1000-1200 m² lake formed at Werner vent in December 2004 sourced by lava flowing from a crater formed in 1993 by a phreatic eruption. The radiative heat flux from the two lakes was measured in December 2004 using a compact infrared (IR) imaging camera. Daily thermal IR surveys from the Main Crater rim provided maps of the lava lake surface temperatures and readily identified sites of upwelling and downwelling. The radiative heat outputs calculated for the Ray and Werner Lakes were 30-35 MW and 20 MW, respectively. We estimate that the magma flux needed to sustain the combined heat loss is ~250-710 kg s⁻¹, and from this result that the minimum volume of the magma reservoir is 2 km³ and the radius of the conduit feeding the Ray lake is ~2 m. magma flux needed to sustain the combined heat loss is ~250-710 kg s⁻¹ and from this result that the minimum volume of the magma reservoir is 2 km³ and the radius of the conduit feeding the Ray lake is ~2 m.

SATELLITE OBSERVATIONS REVEAL LITTLE INTER-ANNUAL VARIABILITY IN THE RADIANT FLUX FROM THE MOUNT EREBUS LAVA LAKE

Robert Wright, Eric Pilger

Satellite remote sensing represents a mature technology for long-term monitoring of volcanic activity at Mount Erebus, either independently or as a complement to field instrumentation. Observations made on 4290 discrete occasions over a six year period by NASA's Moderate Resolution Imaging Spectroradiometer (MODIS) indicate that the radiant flux from the volcano's summit crater (and by inference, the lava lake contained therein), while variable on the time scale of days to weeks, has varied little on an inter-annual basis over this period. Such heat flux time-series have been shown to act as a reliable proxy for general levels of activity at erupting volcanoes around the world, particularly when these time-series are of a long duration. The apparent stability of Erebus' power output is in marked contrast to fluxes observed at three other terrestrial volcanoes, Erta 'Ale (Ethiopia), Nyiragongo (Democratic Republic of Congo) and Ambrym (Vanuatu), which, while also hosting active lava lakes, all exhibit much greater variability in radiant flux over the same period of time. The results presented in this paper are confluent with those obtained from geochemical considerations of the Erebus' degassing regime, and confirm that remarkably stable open system volcanism appears to be characteristic of this long-active volcano.

GAS STUDIES

SULFUR DIOXIDE EMISSIONS AND DEGASSING BEHAVIOR OF EREBUS VOLCANO, ANTARCTICA

Dawn Sweeney, Philip R. Kyle, Clive Oppenheimer

Emission rates of sulfur dioxide (SO_2) were measured at Erebus volcano, Antarctica in December between 1992 and 2005. Since 1992 SO_2 emissions rates are normally distributed with a mean of 61 ± 27 Mg d^{-1} (0.7 ± 0.3 kg s^{-1}) (n= 8064). The emission rates vary over minutes, hours, days and years. Hourly and daily variations often show systematic and cyclic trends. Long-wavelength, large amplitude trends appear related to lava lake area, but are likely controlled by processes occurring at depth. Time series analysis of continuous sequences of measurements obtained over periods of several hours reveals periodicity in SO_2 output ranging from 10 to 360 minutes, with a 10 minute cycle being the most dominant. Closed and open-system degassing models are considered to explain observed variable degassing rates. Closed-system degassing is possible as rheological stiffening and stick/slip may occur within the system. However, the timescales represented in these models do not fit observations made on Erebus. Open system degassing fits the observations collected as the presented models were developed for a system similar to Erebus in terms of degassing, eruptive activity and process repose time.

VOLCANIC EMISSIONS OF METALS AND HALOGENS FROM WHITE ISLAND (NEW ZEALAND) AND MT. EREBUS (ANTARCTICA) DETERMINED WITH CHEMICAL TRAPS

Lois Jean Wardell, Philip R Kyle, Dale Counce

Volcanic emission rates of As, Sb, Pb, Hg, Se, Cl, and F were determined at Mt. Erebus, Antarctica, and White Island, New Zealand, using chemical traps containing 4N NaOH solutions. The trace metal fluxes were determined using the species to S ratios in the solutions with independently determined SO2 emission rates measured by correlation spectrometry at the two volcanoes. At Mt. Erebus, fluxes for the metals Pb and Hg were $2.0x10^{-4}$ and $8.1x10^{-6}$ kg s^{-1}, respectively. Fluxes for Cl, F, As, Sb and Se (0.35, 0.15, $2.5x10^{-4}$, $1.2x10^{-5}$, and $4.5x10^{-6}$ kg s^{-1}, respectively) agreed within error limits for values determined previously by the LiOH impregnated filter method (Zreda-Gostynska et al., 1997), demonstrating the utility of the chemical trap method. Values for As/S ratios may be correlated with changes seen in the frequency and style of eruptive activity that resulted from a magma injection into the system, reducing the As/S ratio from $7x10^{-4}$ to $3x10^{-4}$. At White Island, chemical traps yielded fluxes of Cl = 0.90, F =0.0079, Pb = $2.7x10^{-4}$, Hg = $1.1x10^{-5}$, As = $1.3x10^{-4}$, Sb = $1.9x10^{-5}$ and Se = $1.5x10^{-5}$ kg^*s^{-1}. Samples collected 600 m downwind of the Inner Crater were comparable to samples collected adjacent to the main gas vent, showing that this method can be used when near access to a degassing vent is not possible.

PROBING THE MAGMA PLUMBING OF EREBUS VOLCANO, ANTARCTICA,BY OPEN PATH FTIR SPECTROSCOPY OF GAS EMISSIONS

Clive Oppenheimer, Philip R. Kyle

Gas emissions from Erebus volcano, Antarctica, were measured by open-path Fourier transform infrared spectroscopy to understand degassing of its magmatic system. Two degassing phonolite lava lakes were present in the summit crater during observation in December 2004. We report analyses of H_2O, CO_2, CO, SO_2, HF, HCl and OCS, (in order of molar abundance) in the 6 plumes. Variations in the proportions of these species strongly reflect the dynamics of degassing, and sourcing of gas from different depths in the magmatic network. The highest observed ratios of CO_2 and H_2O are consistent with gas extracted from the melt at a depth of up to ~2 km below the lava lakes. Magma degassing above this depth contributes to a higher H_2O/CO_2 proportion in the airborne plume. The ratio therefore reflects the balance of deeper vs. shallower contributions of volatiles and, possibly, a combination of closed- and open-system degassing. We observe a strong contrast in HF content in emissions from the two lava lakes, which we attribute to differing levels of magma ascent and/or cooling and crystallization of the magma supply. Fluxes of all gas species were determined using independent SO_2 flux determinations and measured gas ratios. In the case of CO_2 and water, ~1 and ~0.4 m3 s^{-1}, respectively, of parental basanite magma are required to sustain the calculated output. The discrepancy between the two figures is readily explained by sequestration of part of the magma supply at depth such that it only partially degasses its complement of water.